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VEGETATION STANDING CROP OF THE GREY LAVA FLOWS AND OF THE EASTERN COASTAL PLAIN ON MARION ISLAND

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ABSTRACT

On sub-Antarctic Marion Island, slope plant communities support higher standing crops than do mire and fjaeldmark communities. Due to their predominance on grey lava flows, however, mire and fjaeldmark contribute 98% of the overall standing crop of vegetation occupying these flows. Standing crop values of grey lava plant communities are substantially lower than those previously reported for the corresponding communities on black lava. Data from black and grey lava vegetation covers are combined according to the proportionate representation of each lava type on the island's eastern coastal plain, yielding an estimate of the overall vegetation standing crop of this larger area. Marion Island vegetation possesses a higher above-ground, but lower below-ground standing crop than most comparable, low-growing northern hemisphere tundra vegetations. This supports previous observations that conditions for plant growth are less severe in sub-Antarctic than in low Arctic and sub-Arctic regions.

UITTREKSEL

DIE VEGETASIE STAANDEOES OP DIE GRYS LAWA GEBIEDE EN DIE OOSTELIKE KUSVLAKTE VAN MARIONEILAND

Op die sub-Antarktiese eiland Marion toon plant gemeenskappe van die hange op grys lawa hoër staandeoeste as moeras en fjaeldmark gemeenskappe alhoewel die twee laasgenoemde 98% van die staandeoes van die grys lawa gebiede as geheel bydra weens hulle oorheersing in die gebiede. Die staandeoeste van die plantgemeenskappe op grys lawa is aansienlik laer as die van ooreenstemmende gemeenskappe op swart lawa. Die vegetasie van die laagliggende ooste gedeelte van die eiland besit 'n hoër bogrondse staandeoes maar 'n laer ondergrondse staandeoes as in soortgelyke vegetasies van die toendra van die noordelike halfrond. Dit bevestig vorige waarnemings dat toestande vir plantegroei in die sub-Antarktiek minder nadelig is as in sub-Arktiese en Arktiese streke.

INTRODUCTION

Marion Island (46°54′S, 37°45′E) is volcanic in origin and is composed of two distinct lava types, a grey preglacial and a black postglacial eruption. Situated in the sub-Antarctic region the island experiences low temperatures (annual mean 5,1°C), high humidities (annual mean 83%) and a high incidence of gale-force winds. The island's biota lacks in species diversity and only 35 vascular plant species (all low-growing graminoids and dwarf shrubs) occur in the vegetation. Due to the inclement weather conditions only the lowland areas (below 500 m) support closed plant communities, the mountainous interior being occupied largely by permanent

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ice and snowfields and bare, rocky peaks vegetated only by lichens and a few mosses. In many respects Marion Island can be considered to possess a tundra-type biome and comprehensive descriptions of this biome are provided in Van Zinderen Bakker, *et al.*, (1971) and Smith (1976).

The coastal plain on the northern, eastern and south-eastern portions of the island forms an area 4–5 km wide, rising gently from sea-level to the foot of the mountainous interior at about 300 m. In this account, the term *eastern coastal plain* is used to describe this whole coastal region, distinguishing it from the western coastal plain which is much narrower (about 1 km) and occupied largely by halophytic plant communities capable of withstanding the large amounts of sea-spray deposited onto the surface by the strong, predominantly westerly, winds.

Black and grey lava types are well represented on the eastern coastal plain, forming approximately 73% and 27% respectively of the area below 500 m (estimated by planimetry from the geological map of Verwoerd and Langenegger, 1971). There is a striking contrast between the formerly glaciated grey lava areas and those which have subsequently been covered by younger black lava flows. The latter generally form a hummocky, well vegetated mosaic of herbfield, mire and fjaeldmark while the smooth topography of the glaciated areas offers little protection from wind erosion and consequently supports a sparser flora, mostly open fjaeldmark on the ridges with mire vegetation occupying the numerous ill-drained basins. Slope areas supporting plant communities similar to those prevalent in black lava areas are uncommon.

The standing crops of plant communities occurring on the black lava flows are provided in Huntley (1972) and Smith (1976). This paper presents corresponding data for plant communities situated on the grey lava areas as well an an assessment of the overall standing crop of the vegetation of the island's eastern coastal plain. Skua Ridge, approximately 1½ km north of the meteorological station, is typical of the grey lava flows of this coastal plain and a 1,3 hectare area, approximately 750 m inland and 80 m above sea level, formed the intensive study site for the investigation.

TERMINOLOGY AND METHODS

1. *Terminology*

Biomass refers to living plant matter while *standing crop* is the sum of alive and dead material. Because of difficulty in distinguishing below-ground living and dead material, these two components are not reported separately but rather the composite figure (below-ground standing crop) is presented.

2. *Methods*

The standing crop estimates presented in Table 2 reflect the average maximum standing crops (oven-dry basis) attained by the plant communities in the study site during the 1971/2 growing season. The harvest method employed is described in detail in Smith (1976).

The relative areas occupied by each plant community on the surface of the study site are not representative of their proportions in the grey lava regions of the island's eastern coastal plain as a whole. In order to provide an estimate of the overall vegetation standing crop of these regions, an assessment of the true extent of each community within the larger area had to be made. Several traverses of the Skua Ridge, Long Ridge and Kerguelen Rise – Stony Ridge areas were marched on fixed compass bearings and the number of footfalls, or footsteps, in each plant community encountered on the marches was recorded. Points were 75 cm apart and this distance was kept constant by a piece of string tied between the walker's feet. This modified step-point method proved to be a rapid means of assessing the relative areas occupied by the different plant communities.

RESULTS AND DISCUSSION

1. *Description of the plant communities*

The topography of Skua Ridge is that of a flat, exposed plateau consisting mainly of fjaeldmark (possessing a thin, discontinuous layer of soil and strewn with slabs of frost-shattered grey basalt; Figure 1) and mire vegetation (occupying depressions in the plateau and overlying wet, usually amorphous, peat deposits;

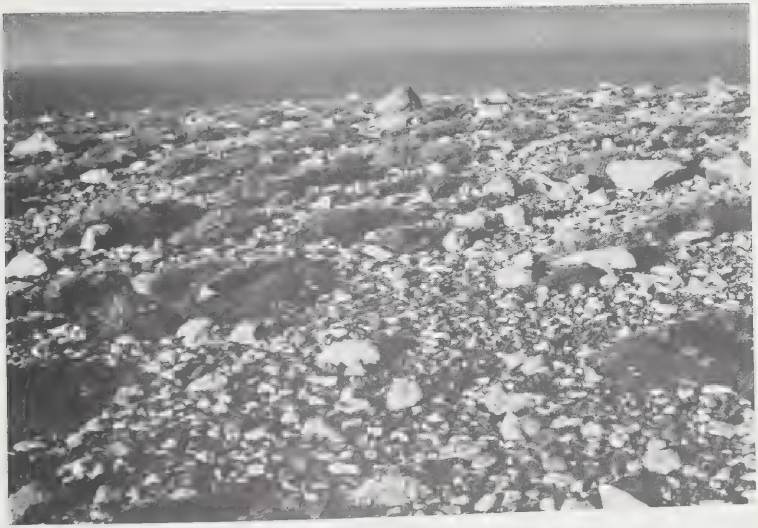

FIG. 1.

Fjaeldmark on grey lava. Cushions of *Azorella selago* support scattered *Agrostis magellanica* plants. Distance to land horizon approximately 20 m.

TABLE 1.

Percentage aerial cover values of component species in plant communities of grey lava flows and the proportionate representation (%) of these communities on these flows.

Plant Community	*B. penna-marina*	*Poa cookii*	*Azorella selago*	*A.* [1]*magellanica*	*A.* [2]*magellanica*	Bryophytes	Algal mats	Other	% area occupied on grey lava
Slope complex									
Closed-fernbrake	95	1	5	tr	nil	nil	nil	tr	0,04
Open-fernbrake	12	1	38	50	0,5	nil	nil	tr	1,10
Tussock grassland	tr	70	15	10	nil	30	nil	tr	0,43
Fjaeldmark									
A. selago fjaeldmark	tr	0	16	tr	4	1–2	nil	tr	39,30
Mire									
A. [2]*magellanica* mire	nil	nil	0,5	nil	40	40–70	0–2	10[3]	59,00

[1] *Acaena magellanica*

[2] *Agrostis magellanica*

[3] Including *Uncinia dikei* (3%), *Juncus scheuchzerioides* (5%) and *Ranunculus biternatus* (2%).

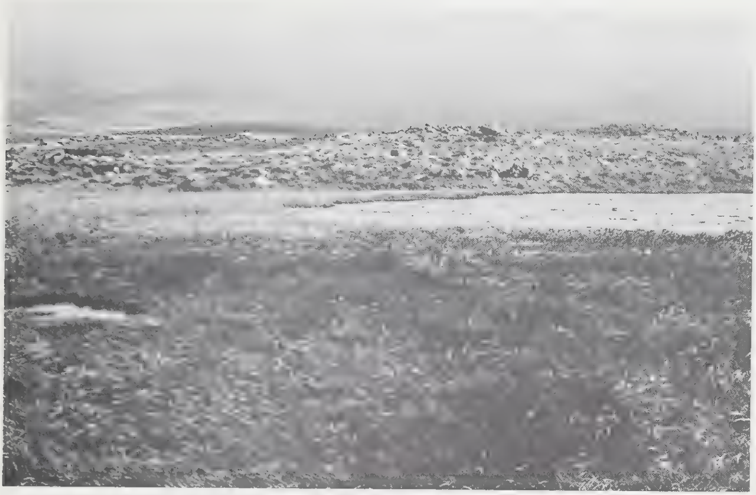

FIG. 2.
View of the southern portion of the grey lava study site with mire in foreground and fjaeldmark in background. Distance to lake approximately 20 m.

Figure 2). Two slopes supporting slope plant communities occur in the study site and are covered by a closed *Blechnum penna-marina* (Poir) Kuhn fernbrake community and, on more exposed aspects, by a stunted open-fernbrake community in which there is a greater importance of *Acaena magellanica* Lam. Vahl and *Azorella selago* Hook. f. A small area on one slope is occupied by burrowing bird species and supports a dense *Poa cookii* Hook. f. – *Acaena magellanica* tussock grassland. A summary of the floristic compositions of the plant communities is presented in Table 1. Also provided in the table is the percentage surface area occupied by each plant community on grey lava flows of the eastern coastal plain as a whole. The predominance of mire and fjaeldmark vegetations on these flows is apparent in the table.

The mire community is similar in species composition to black lava mire areas (Smith, 1976), being dominated by *Agrostis magellanica* Lam. and several bryophyte species (especially *Jamesoniella colorata* (Lehm.) Schiffn. and *Racomitrium lanuginosum* (Hedw. Brid.). The fjaeldmark vegetation consists almost entirely of *Azorella selago* cushions scattered within a loose aggregation of rocks and pebbles (Figure 1).

2. *Standing crops of plant matter in the communities*

The standing crops of the plant communities in the grey lava study site are presented in Table 2. Also included in Table 2 are the contributions (in kg ha^{-1}) of

TABLE 2.

Standing crops (g m^{-2}) of plant communities on grey lava flows and the contributions of these communities to the standing crop (kg ha^{-1}) of the vegetation of these flows.

	Above-Ground					Below Ground S.C.	Total Stand. Crop	S.C. in average ha.
	Biomass			Dead O.M.	Total S.C.			
	Vasc.	Crypto.	Total					
Slope Complex								
Closed-fernbrake	310±16	—	310±16	872±85	1 182	3 156±310	4 338	17
Open-fernbrake	439±16	—	439±16	1 260±106	1 699	1 238±83	2 937	323
Tussock grassland	735±29	70±23	805	187±53	2 676	2 687±211	5 363	230
Fjaeldmark								
A. selago fjaeldmark	111±12	—	111±12	645±38	756	418±61	1 174	4 614
Mire Complex								
A. magellanica mire	97±18	147±76	244	242±63	486	1 778±313	2 264	13 358

these communities to the total standing crop of an average hectare of the grey lava flows of the eastern coastal plain, according to their proportionate representation as presented in Table 1.

Plant communities of the slope complex support far higher standing crops of plant matter than do those of mire and fjaeldmark areas. This is in accordance with the data from black lava regions (Smith, 1976) and with observations on other hummocky and hillocky tundra areas (Rodin and Bazilevich, 1967). Surprisingly, the open-fernbrake community exhibits a greater above-ground biomass and standing crop than does closed-fernbrake. Although this difference is significant at P = 0,001, sampling errors in clipping and subsequent sorting of the harvested material are responsible for the high above-ground standing crop component values for open-fernbrake. *Acaena magellanica* accounts for 50% of the aerial cover of this vegetation (Table 1) and the large perennial stems contribute 46% of the above-ground biomass. This latter figure is erroneously high as it is difficult to distinguish the uppermost portions of *Acaena* roots from the stem material (Walton, 1976) and in open-fernbrake communities on grey lava wind erosion exposes some of the roots at the surface so that these were included in the above-ground component during sorting. This also accounts for the low below-ground standing crop estimate for this community. Large amounts of litter accumulate in *Azorella selago* cushions and this also adds substantially to the above-ground standing crop in open-fernbrake. Both open- and closed-fernbrake on grey lava possess lower standing crops (66% and 71% respectively) than do the corresponding black lava communities (Smith, 1976).

Tussock grassland exhibits the highest above-ground and total standing crops of all grey lava plant communities. This is due to the large amounts of living and dead plant material which accumulate in the *Poa cookii* swards and to the large perennial stems of *Acaena magellanica* and supports previous observations on sub-Antarctic tussock grasslands (Macquarie Island: Jenkin and Ashton, 1970; South Georgia: Walton, Greene and Callaghan, 1975). The above-ground standing crop (2 676 g m^{-2}) for grey lava tussock grassland agrees closely with that previously measured on a similar tussock grassland on black lava (2 617 g m^{-2}, Smith, 1976).

Mire vegetation possesses very low amounts of living and dead above-ground vascular plant material and consequently exhibits the lowest above-ground standing crop of all plant communities on grey lava. Sixty percent of the aerial biomass in mire areas is attributable to bryophytes. The above-ground biomasses of grey and black lava mires are approximately similar (97 ± 18 g m^{-2} and 117 ± 29 g m^{-2} respectively). Algal mats do not contribute significantly to the standing crops of mire communities on either lava type (Croome, 1973; Smith, 1976).

Fjaeldmark supports the lowest above-ground biomass and total standing crop of all grey lava plant communities. Due to the large amount of dead material which accumulates in *Azorella* cushions, however, the above-ground standing crop of fjaeldmark vegetation is substantially greater than that of the mires.

3. *Standing crops of grey lava vegetation and of the island's eastern coastal plain as a whole*

Mire and fjaeldmark communities account for 72% and 25% respectively of the total vegetation standing crop on grey lava flows (Table 2). Thus, despite their high standing crops, slope communities do not contribute significantly to the total standing crop of the vegetation on these flows. The standing crop of grey lava vegetation, based on the proportionate representation of the various grey lava plant communities, is presented in Table 3. The contribution of closed-fernbrake (<0,1%) is ignored in the table. Also provided in Table 3 are the standing crop of black lava vegetation (Smith, 1976) and a combined standing crop value for the vegetation of the island's eastern coastal plain as a whole, based on the proportionate representation of the two lava types in this area.

TABLE 3.
Standing crops (kg ha^{-1}) of vegetation on the island's eastern coastal plain.

	Standing Crop Component (kg ha^{-1}).						
	Above-ground					Below-Ground Total	Total Stand. Crop
	Biomass			Dead O.M.	Total Above		
	Vasc.	Cryp.	Total				
Black lava	3 060	840	3 900	11 050	14 950	22 620	37 570
Grey lava	1 088	870	1 959	4 182	6 140	12 389	18 525
Eastern coastal plain	2 528	848	3 376	9 196	12 571	19 858	32 428

The standing crop components of black lava vegetation are 2 to 2½ times greater than those of grey lava vegetation. This is due to the higher altitude ~~and~~ greater exposure of the grey lava sites and to the importance of mire and fjaeldmark rather than of closed, slope plant communities in these sites.

The above-ground biomass (2 528 kg ha^{-1}) of vascular plants on the Marion Island eastern coastal plain is similar to those (2 180 to 2 500 kg ha^{-1}) of mosaic and hillocky tundra areas consisting of sedges, mosses, lichens and dwarf shrubs of the U.S.S.R. low Arctic and sub-Arctic (Rodin and Bazilevich, 1967) and of sub-Arctic grassland and sedge-swamp communities (2 340 to 2 420 kg ha^{-1}) in Swedish Lapland (Pearsall and Newbould, 1957). A low (848 kg ha^{-1}) cryptogam biomass occurs in the island vegetation, however, in contrast to the dominance of cryptogams at these sub-Arctic and low Arctic areas. The large amount of dead vascular plant material which accumulates in the island vegetation causes the above-ground standing crop (12 571 kg ha^{-1}) to be substantially higher than those of these northern circumpolar tundra vegetations (8 700 to 10 000 kg ha^{-1}).

Data in Bliss (1962) and Scott and Billings (1964) indicate that alpine shrub and meadow communities support much lower above-ground biomasses and standing crops than occur in the island vegetation.

In contrast to the high above-ground standing crop, the island vegetation possesses a lower quantity (19 858 kg ha^{-1}) of below-ground plant matter than do comparable sub-Arctic and low Arctic tundra vegetations (23 070 to 62 260 kg ha^{-1}; Rodin and Bazilevich, 1967), agreeing with similar observations on Signy Island (Edwards, 1973) and South Georgia (Walton, *et al.*, 1975). This supports proposals by Bliss (1970) and Dennis and Johnson (1970) that environmental limitations to standing crop are relatively more severe for the above-ground than the below-ground parts of plants and that although annual below-ground production is lower in the Arctic than in more temperate regions, the roots live longer and decompose more slowly. This longer root life, coupled with a slower decomposition rate, means that the below-ground vegetation standing crops in the cold, often frozen soils of northern circumpolar regions are often higher than in the warmer (and wetter) soils of Marion Island (Smith, 1976).

The high above-ground standing crop of the island vegetation agrees with the view expressed by Walton, *et al.*, (1975) that conditions in the sub-Antarctic region may be considerably less severe than those experienced at other tundra sites and supports Wielgolaski's statement (Wielgolaski, 1972) that in the sub-Antarctic region (Macquarie Island and South Georgia) the growth relationships can be characterised, ecologically, as good.

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